

Backward Causation in Complex Action Model^{*}

— Superdeterminism and Transactional Interpretations —

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Abstract

It is shown that the transactional interpretation of quantum mechanics being referred back to Feynman-Wheeler's time reversal symmetric radiation theory has reminiscences to our complex action model. In this complex action model the initial conditions are in principle even calculable. Thus it

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philosophically points towards superdeterminism, but really the Bell theorem problem is solved in our model of complex action by removing the significance of signals running slower than by light velocity.

Our model as earlier published predicts that LHC should have some failure before reaching to have produced as many Higgs-particles as would have been produced the SSC accelerator. In the present article, we point out that a cardgame involving whether to restrict LHC-running as we have proposed to test our model will under all circumstances be a success.

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1 Introduction

In the previous articles [1] we proposed that one should use the LHC-machine to look for backward causation effects. Indeed, we proposed a model [1, 2, 3, 4] in which the realized history of the universe was selected so as to minimize a certain functional of the history, a functional being the imaginary part of the action S_I [history], which only exists in our model. In general, it is assumed in science that there is no pre-arrangement [5] of initial conditions so as to make special events occur or not occur later. However J. Bell proposed in BBC radio broadcast as a solution to the problems of Einstein - Podlosky - Rosen's "super-determinism" [6] and even more it has been developping to the transactional interpretation of quantum mechanics [7], which involves Feynman-Wheeler's radiation theory[8] that has backward causation in its formalism.

Also, one of the present authors (H.B.N.) and his group earlier proposed models nonlocal in time (and space) [9, 10, 11]. Similar backward causation effects have also been proposed in connection with the story that e. g. humanity would cause a new vacuum to appear, "vacuum bomb," by one of the present authors (H.B.N.) and collaborators [12].

Our proposal is to test if there should perhaps be such pre-arrangements in nature, that is, pre-arrangements that prevent Higgs particle producing machines, such as LHC and SSC, from being functional. Our model with an imaginary part of the action [1, 14] begins with a series of not completely convincing, but still suggestive, assumptions that lead to the prediction that large Higgs producing machines should turn out not to work in that history of the universe, which is actually being realized.

The main points of the present article are the following two points:

- A) To argue that our "model with imaginary action"[1-4] is a very natural type of model if one decides to go for Bell's proposal of superdeterminism [6] or the transactional interpretation.
- B) To argue that by making the type of experiment testing our model by a card game about the putting restrictions on the running of LHC can only seem to

be successfull.

These points will be explained below:

A) The point of superdeterminism is to overcome the trouble of the Bell's theorem with quantum mechanics and very general assumptions of locality, by discarding the assumption that the experimentalists in each of the entanglement connected objects have a “free will” to choose what they want to measure. Rather the idea is that they could NOT have chosen to measure anything different from what they indeed go to measure. I.e. it is at least as if the decision of these experimentalists were fixed so that it could perhaps even be something that were in principle calculable. At least it should not be allowed to argue about other possibilities for their choice of measurements to perform than the ones they really do choose. In that case of course the whole story of the Einstein-Podolsky-Rosen or equivalently Bell's theorem has no point. If you only measure whatever you measure it is only that element of reality that corresponds to that which is relevant and no paradoxes come in.

Since our model leads in the classical approximation to be a model even for the initial conditions so that indeed *everything* get determined by in principle - but not in practice – from pure calculations only using the coupling constants including their imaginary parts as input is an eclatant example of superdeterminism (at least classically). We want to argue in section 2 below that indeed something like our model is strongly called for by the problems of measurement theory, as is also stated in the proceedings at the Vexjo conference by one of us [13].

B) The plan behind the practical experiment, which we proposed, was to produce some random numbers—partly by drawing cards and partly by quantum random number generation – and then let these random numbers be translated, according to the rules of the game, into some restrictions on the luminosity or the energy or both of the LHC. Thus LHC might, for instance, only be allowed to run up to a certain beam energy. I. Stewart [14] proposed that pauses are determined by random numbers.

The idea is merely to require any restriction at all for LHC with probability p that is deemed, by the rules of the game, to be very small. The probability p for a “close LHC” card is $p \sim 10^{-6}$ or so [1].

It is clear that even a small probability restriction enforced on LHC, its luminosity or beam energy, means an artificially imposed – one would say, ignoring our

type of model – risk for the LHC project.

It is, however, the main focus of the present paper to point out (as was briefly stated in the previous article [1]) that even though our proposed project of restricting LHC according to random numbers seems to give rise to a loss, in fact, whatever happens seems – initially at least – to be a gain, a success!

That a success in this sense is guaranteed to be the result seemingly with almost 100% certainty (but in reality not quite 100%) is demonstrated in the present article.

The point really is that seeing any restriction coming up from a card game of a type that should happen with probability of 10^{-6} is already evidence for our model, which would thus be discovered by such a card draw.

Of course the whole exercise of making the proposed card game experiment looking for some backward causation of the type we propose would be futile if such an effect were already excluded by earlier experiments. If indeed we should look for completely disastrous bad luck for any attempt to produce just a single Higgs particle, presumably the Tevatron or FNAL in Chicago would already present a counter example. Although not a single Higgs particle has been safely recognized to have been produced at the Tevatron one expects that according to theoretical expectations in say Standard Model several thousands of them would already have been produced, although even that is not sufficient for a discovery, since only exclusions of mass regions so far were found. But the LHC accelerator as well as the SSC would, if working, produce much more Higgs particles in the long run than the Tevatron. So it is certainly a possibility that the effect causing backward particles achieved in the LHC and the in 1993 stopped SSC, while being insignificant in the Tevatron case.

It has also been proposed that the mere observation of cosmic rays with sufficient energy so as to even on fixed target produce Higgs particles should represent an argument against the possibility of the effect we propose to investigate. However, although we certainly would, if such an effect existed, predict that the amount of cosmic rays with such energies would be reduced by the backward causation effect, one might imagine that sources of cosmic rays might be directed to send their radiation in the direction of regions with low density of stars and planets so as to avoid Higgs production, but we do not have sufficient statistics to have any measurement of whether there should –say 300,000 Higgses– statistically be any effect

of that type; for that our understanding of what the amount of cosmic rays without there being such an effect is too poor.

2 Relation of Super-determinism to our complex action model

We have already remarked in the introduction that in our complex action model the imaginary part of the action comes to play the role of determining the initial conditions. If we indeed denote the complex action

$$S[\text{path}] = S_R[\text{path}] + iS_I[\text{path}], \quad (1)$$

where S_R and S_I are then the real and imaginary parts respectively we have approximately that among all the solutions to the classical equations of motion in ignoring the imaginary part approximation

$$\delta S_R = 0, \quad (2)$$

the solution with the minimal (i.e. most negative) $S_I[\text{sol}]$ is the one which we live through (i.e. the one realized). That is to say the formula in our complex action model for the history of the universe to be selected as the one realized becomes

$$S_I[\text{sol}] \text{ will be minimal.} \quad (3)$$

The fact that we have such a formula – wherein the mathematical expression for S_I in terms of the field(development)s is very similar and analogous to the usual Standard Model action expression, except that the coefficients deviate – for the realized history *sol* means that even the initial conditions (contained in *sol*) are *calculable* in principle, although not in practice. With such a model as ours in which one thus can calculate “everything” in principle one can especially imagine calculating the choice of the experimentalists in an EPS(= Einstein-Podolsky-Rosen) type of experiment would perform on the particles that were separated in this experiment. Let us remind the reader that in the EPS or Bell-theorem type of experiment a couple of quanta(= particles) are produced in a correlated (entangled) state and successively these particles separate to run in different directions. Further away whereto these separated particles run two different experimentalists teams with their detections

determine measure properties of the particles. It is important that these experimentalists, if they have “free will”, can make their decisions about what properties to measure, the spin component along what direction say, or momentum or position, *after* the particles are already widely separated. Of course in our model with complex action, like in even just usual deterministic models, the “free will” will only be something in our fantasies, since we could in our model in principle even have calculated what their choices of quantities to be measured would be.

The problem with quantum mechanics associated with Bell’s Theorem is that under mild assumptions, mainly that no signal can go arbitrarily fast from the one measurement place to the other one so as to communicate the experimentalists choice, the quantum mechanical statistical predictions are not consistent. If one takes the point of view that we only need to consider the truly realized situation, i. e. choice of experiments measuring on the particles, but can ignore totally the “only fantasy” possibilities associated with the make up of a “free will” feeling for the experimentalists, then Bell’s theorem falls away and quantum mechanics has no Bell’s theorem problem.

Thus logically we may say that our model even strengthens the application of superdeterminism to escape the Bell’s theorem problem. We say that our model strengthens the superdeterminism because it makes the initial state and thus the deterministically determined experimentalist decisions even calculable, so that a requirement that we should be allowed to vary at least the initial conditions in deriving Bell’s theorem requirements would no longer hold in our model.

Now, however, we shall argue in the next section that in spite of our model in this way strengthening the ground for superdeterminism, it is in fact another feature of our model that removes the Bell’s theorem troubles in it. In fact the point is rather that once we have effectively backward causation – so that e. g. the potential switch on of SSC to produce many Higgs bosons can backwardly cause the Congress of the United States to stop the funding – then the rule that a signal cannot move with arbitrarily high speed no longer makes sense. The signal could instead move slowly along in the future and then go backward in time using the feature of backward causation in our model.

3 Analysis of the way our model solves the EPS-Bell's Theorem problem

Really as Bell himself were aware – and why he thus did not like superdeterminism as the way out for quantum mechanics – there can be a lot of small details going on in an in practice very hard to control way and these details can influence the experimentalist's decisions. Such details are e.g. the reasoning in their brains and really may well represent their “free will”. We believe that indeed a superdeterminism solution solving the Bell's theorem problem for quantum mechanics by postulating that even these “free will” – simulating details leading forward to the experimentalist's decisions can be somehow integrated up and calculated through by the particle choosing its property when measured is a somewhat unhealthy philosophy. How should indeed a particle say B at site B where a measurement is made “know” and “understand” the contemplations in detail of the experimentalists at the other site A? It sounds healthier to make an assumption that such detailed calculations as the ones in the experimentalists of team A cannot get calculated through at the observation site B. Supplementing quantum mechanics with locality etc by such a reasonable extra postulate the loophole in the Bell's theorem trouble for quantum mechanics would be closed. With such an extra reasonable assumption quantum mechanics would be truly in trouble. Our strengthening by making the initial state “calculable” in principle will a prior not help much against the reasonable assumption suggested. So as far as the true superdeterminism solution to the Bell's theorem problem for quantum mechanics our model does not help much.

There is, however, another way in which our model may help more realistically quantum mechanics against the Bell's theorem problem. Since the formula $S_I[\text{history}]_{\text{minimal}}$ has in the integral form

$$S_I[\text{history}] = \int_{\text{all times}} L_I(\text{history}(t)) dt \quad (4)$$

contributions from all times, from the beginning of times to the end, it also includes contributions from what is future for us to say. In order that our model shall have a chance of being viable we must of course hope or speculate that e.g. because of the special conditions in the inflation time, the contributions to $S_I[\text{history}]$ from $L_I(\text{history}(t))$ for time t in the inflation era were by far the most important, so that

what happened in the inflation-era dominated the selection of what history were the one to be realized (to be the one we live through now). Only with such an assumption of the inflation-era contribution to the $S_I = \int L_I dt$ integral dominating the selection of the initial conditions (the solution) will agree with our normal experience with second law of thermodynamics, meaning that only the start were strongly organized in the sense of having low entropy and essentially nothing being prearranged by having fine tuned initial conditions destined to make future thing happen. However, in our complex action model there should be at least some seeming attempts to such prearrangements, meaning that there is in our model in principle happening events not expected statistically in the usual theory, so that one might denote them as “miracles” or “antimiracles” if it is something bad. Usually, however, we expect that the contributions from the era such as the inflation era around the “Big Bang” time (if there were a Big Bang) would dominate.

When, however, we consider a quantum experiment with a measurement, the result of which seemingly independently of the initial conditions can with finite non-zero probabilities obtain different measured values, it becomes suggestive that the future contribution $\int_{t_{\text{exp}}}^{\infty} L_I dt$ could become important where t_{exp} denotes the time the experiment is performed. We therefore in our model suppose that the outcome of a quantum experiment is not a priori just pure fortuitousness or accident, but actually depends on the (future) contribution to the imaginary part of the action $\int_{t_{\text{exp}}}^{\infty} L_I dt$. That is to say, we expect that the outcome of the measurement is that result which minimizes the contributions $\int_{t_{\text{exp}}}^{\infty} L_I dt$ to S_I depending on this outcome.

If we have, as we now assume about our model, a theory in which the outcome of a quantum measurement is selected by minimizing an integral $\int_{t_{\text{exp}}}^{\infty} L_I dt$ extending into the far away future for the whole world, then the worry about signals going between the sites A and B for the measurements in the EPS-type experiment faster than light or arbitrarily fast loses its interest. The point namely is that to avoid Bell’s theorem troubles needed faster than light signals can be replaced by signals reaching the future of the particles measured upon, because it is the future of the particle (roughly speaking) that determines the result of the quantum measurement. Really it is not so much the future of the particle itself as of the results of the measurement as propagated by publications etc into the future that matters for the $\int_{t_{\text{exp}}}^{\infty} L_I dt$ integral to be minimized for telling the result of the measurement.

You might describe this picture of the measurement results being determined by minimizing the future part of the imaginary part of the action S_I , called $\int_{t_{\text{exp}}}^{\infty} L_I dt$, crudely as the information first going forward in time where it all the way contributes to $\int_{t_{\text{exp}}}^{\infty} L_I dt$ and cause what we call backward causation an influence backward in time determining the measurement results.

To make clearer the way our model treats the Bell's theorem situation, we could hypothetically imagine that the two sites of measurement A and B were kept in all the future isolated. Then the measurement results, in our model determined (in a complicated way) from the future integral contribution $\int_{t_{\text{exp}}}^{\infty} L_I dt$, could not get correlated. In other words, the anti Bell's theorem strange correlation (or any correlation) between the measurement results provided the two sites A and B have a common future, which can contribute to $\int_{t_{\text{exp}}}^{\infty} L_I dt$ and thereby make the minimization of this integral provide the correlation.

This “explanation” of the violation of Bell's theorem by the future contributions to S_I , i. e. $\int_{t_{\text{exp}}}^{\infty} L_I dt$, deciding the measurement results in our model is nicer than the genuine superdeterminism, because it does not require the complicated contemplations of the experimentalist teams to be “known” and “understood” by any particles.

Really the usual Copenhagen interpretation (or Born) rule is approximately reproduced in our model by making an approximation

$$|B(t)\rangle\langle B(t)| \sim 1, \quad (5)$$

where the ket $|B(t)\rangle$ and its bra $\langle B(t)|$ is given by a functional integral over the exponentiated action from the after t_{exp} era only

$$S_{\text{after } t_{\text{exp}}} = \int_{t_{\text{exp}}}^{\infty} L dt. \quad (6)$$

I. e. we defined previously in a basis consisting of basis vectors $|\vec{q}\rangle$,

$$\langle \vec{q} | B(t) \rangle \doteq \int_{\text{with conditions path}(t)=\vec{q}} e^{\frac{i}{\hbar} S_{\text{after}(t)}(\text{path})} D\text{path}. \quad (7)$$

(paths from path t_{exp} to ∞)

We thus see that although everything even what really happens and what gets measured is in our model (super) determined in the sense that it is even in principle

calculable, the important way in which our model can be claimed to solve the problem with Bell's theorem is rather that it by having dependence on the future via the integral $\int_{t_{\text{exp}}}^{\infty} L_I dt$ gets information/ a signal backward in time to determine the outcome of the measurement. After such a backward in time signalling is allowed, the locality principle formally implemented by the (complex) action being of the form

$$S[\text{path}] = \int L(\text{path}(x), \partial\text{path}(x)) \sqrt{g} dx, \quad (8)$$

where the Lagrangian density $L(\text{path}(x), \partial\text{path}(x))$ only depends on the field development called path in the infinitesimal neighborhood of the spacetime point x , i. e. on $\text{path}(x)$ and its first derivatives $\partial\text{path}(x)$, can still be compatible with an effective arbitrarily fast information transfer. It is by means of backward causation via the $\int_{t_{\text{exp}}}^{\infty} L_I dt$ dependence our model – in a somewhat reasonable thinkable way – circumvents one of the assumptions behind the Bell's theorem and thus its trouble for quantum mechanics.

4 The Trasnactional Interpretation

There is another proposal for quantum mechanics interpretation, which is even more similar to ours than the just discussed superdeterminism, and that is the transactional interpretation. In fact this transactional interpretation has formally the interesting common feature with our model: Formal influence from the future.

In the transactional interpretation this formal backward causation or influence from the future is at least clearly alluded to by the fact that the transactional interpretation on the Feynman-Wheeler electrodynamics. In this Feynman-Wheeler theory of electrodynamics the usual boundary conditions used to derive electromagnetic radiation to be described by retarded waves is replaced by a time reversal invariant boundary condition. This Feynman-Wheeler postulate is that an electrically charged object sends out both a retarded and an advanced contribution to the electromagnetic fields so that the total emission is time reversal invariant. This means that formally fields propagate both backward and forward in time. Thus formally the Feynman-Wheeler theory has influence from the future built into it. It is nontrivial in their theory to argue that in practice we obtain seemingly only the

retarded waves, and the argumentation does not work in all cosmological pictures. It is namely based on a discussion in which the absorber of the light is strongly needed.

When therefore the transactional interpretation is based on the wave function for the photon (\sim essentially the electromagnetic field) is influenced by charged matter in just the way proposed by Feynman-Wheeler it looks a priori as if the transactional interpretation is also easily going to contain influence from the future. However, it is claimed by the proponents of the transactional interpretation by Cramer [7] that one can distinguish a strong and weak principle of causality. The weak principle of causality which only claims that a cause shall come before the effect when it applies to macroscopic observations and observer-to-observer communication. But Cramer claims: there is no present experimental evidence in support of any causal principle stronger than the “weak principle”. To this interpretation even opens up for backward causation on the microlevel, since strong causality is not hold up. Another point pointing towards our model of complex action is the occurrence of two wave functions: OW (“offer wave”) and CW (“confirmation wave”). This has similarities to the $\langle q|A(t)\rangle$ and $\langle B(t)|q\rangle$ wave functions defined in our functional integral based on “complex action model” by the following “half time” functional integrals

$$\langle q|A(t)\rangle = \int_{\substack{\text{with boundary} \\ \text{conditions} \\ q'=\text{path}(t)}} e^{\frac{i}{\hbar} \int_{-\infty(\text{beginning})}^t L(\text{path}, \partial\text{path}) dt} D\text{path}_{(\text{half})}, \quad (9)$$

and

$$\langle B(t)|q'\rangle = \int e^{\frac{i}{\hbar} \int_t^\infty L(\text{path}, \frac{d\text{path}}{dt} dt} D\text{path}_{(\text{half})}. \quad (10)$$

4.1 More review of transactional interpretation

As far as we understand the point of the transactional model is that echoes of advanced waves responding retarded and advanced considered in a pedagogical time finally leads to a total field which obey:

- a) the usual type of boundary conditions of no wave before emission and no wave after absorption.

- b) some quantization conditions, e.g. supposedly that the energy is given by a Planck quantization rule.

We must think about it that the field being nonzero region gets concentrated along a narrow track in space(time) connecting the emitter to the absorber. If this is a correct interpretation of the transactional model then we see that the direction of motion of the emitted photon is from the start geared to reach its absorption place, the absorber. But that means that it is indeed strongly influenced by the future. This is of course what is expected in a model based on the backward causality containing Feynman-Wheeler theory. It means, at least, that in principle now the influence from future has sneaked into the transactional interpretation scheme, then it may turn out to not be there macroscopically at the end though.

4.2 Is our complex action model equivalent to the transactional interpretation?

Although both our model of complex action and the transactional interpretation model are both characterized by influence from the future, they are not exactly the same, since we have different details for the influence from the future. In fact, there is in our model in principle a series of parameters in the form of the imaginary part of the action $S_I = \int L_I dt$ to be chosen, before we have a definite model, while in the transactional interpretation model one uses the Feynman-Wheeler time reversal symmetric emission-rule (\sim boundary condition) to tell how future influences past.

But in a general way we may bring the correspondence between the two models to be very close each other indeed. Presumably the best way to make the correspondence be there is to use the second quantized theory in the field theory language in the functional integral taken as fundamental in our model.

That is to say, we take our abstract “path” to mean a thinkable develop of all the fields (supposed for simplicity only bosonic fields $\psi(X^\mu)$). This means that the phase space – in this thinking on our model – is a space of infinitely many dimensions the coordinates of which are partly the fields $\psi_i(\vec{X})$ and partly their conjugate fields.

Now it is the crucial feature in our model with complex action and use action integral over all time (including both all past and all future) that the initial conditions or rather a solution to the equations of motion gets field (and is in principle

calculable). This classical solution singled out by means of the imaginary action S_I being minimal is a classical solution describing a path through all times. It thus even in principle makes it possible to calculate the outcome of quantum experiments (in our complex action model). Thinking upon this model with the fields as the variables describing the path we get thus our model to – up to a few small splittings of the track – deliver as in principle (but not in practice) a classical solution to the field development. But now such a classical field development is what from the only quantized point of view is a specific development of the wave function. This wave function now can be considered as it is in the transactional interpretation just an ordinary (meaning well-defined classical) field! In this way you can say that our complex action model taken as a theory for the fields deliver just the picture of the transactional interpretation.

4.3 How comes single quantization about?

With such a making the wave function or say better the fields become classical solutions one might become worried about how we can get say the quantization of the energy of a photon by $\hbar\omega$, where ω is the frequency.

In our model it cannot really come about unless we allow that there typically will be more than just classical solutions selected, but rather a discrete series of rather close to each other solutions. In the case of a photon being transmitted from some emitter to an absorber over a long (space and) distance these close to each other but different classical solutions –still relevant/contributing to our functional integral– would be solutions within a range of close by numbers of turns in the oscillations of the field from emitter to absorber. But now each extra turn in the field oscillation will give an extra phase factor in our “fundamental” functional integral. These different “neighboring” routes will only add up constructively provided the total phase difference between the contributions from the different classical (field) solutions happen to be (at least approximately) zero. Such a condition for constructive interference between contributions in the Wentzel-Dirac-Feynman integral from various only a but from each other deviating classical solutions could lead to the quantization rule in the single quantized language.

It seems that in the transactional interpretation the quantization of energy and momentum is imposed as an extra condition without any explanation behind it.

That would correspond to our model if one would make quantization without having our functional integral on a level more fundamental, then namely the phase-factor from the behind functional integration would have no place in the picture. One would have to put it on extra as a kind of Bohr-quantization condition.

4.4 What to conclude from the tight connection of our model with transactional interpretation?

One can look at the close coincidence of our complex action model with transactional interpretation in two opposite directions: Believing transactional interpretation and show that it is a model “of our type” thus supporting such models. Or one could oppositely believe in our model and say that derive not exactly the conventional model of transactional interpretation, but a transactional interpretation type model. The latter does not necessarily have the Feynman-Wheeler’s specific way of sending equal strength wave retardedly and advanced, but which in the important “philosophical” aspects would be just the same: The wave functions (in the single particle picture) could be considered ordinary (\sim classical) fields, there would be influence from the future so that a particle would be guided in the right direction from the start in say Renninger’s negative result experiment.

5 What we need

Even though it is not so much the superdeterminism in our model in the sense of everything being calculable in principle that makes it compatible with the Bell’s theorem and quantum mechanics as its lack of information only going forward in time as usual that causes the compatibility of our model with quantum mechanics and locality our model is nevertheless supported by the troubles of quantum mechanics.

We could generally state that clearly any theory with backward causation like our model would potentially be able to circumvent the Bell’s theorem troubles by via the future forth and back allowing an effect/a signal to go effectively faster than light. Such potential theories with backward causation it would be able to solve the Bell’s theorem trouble. This type of “theory” could be claimed to be supported by the quantum mechanics Bell’s theorem trouble. This fact makes it especially

important to look for any backward causation effects whenever there should be a chance for it. Since we have so far only rather weak evidence for if any even very seldom prearranged events it seems that usual daily life physics should show extremely little backward causation in any viable physics theory. However for much higher energy per particle than in daily life physics we may have yet looked less carefully for prearranged events (\sim miracles). It is therefore to be suggested that, e.g. to look for a possible way out of the Bell's theorem problem, one should at each new accelerator look for prearranged events.

If the prearranging governing (e.g. via the initial conditions) of the world were made to arrange for or arrange for avoiding some phenomenon happening due to high energy accelerators of some sort, the easiest (least miraculous) way to arrange for or avoid such a phenomenon might be to favour or disfavour the very building of the accelerator.

As the example which is favoured by speculations in our model of complex action it could be that there is a special type of particle which if produced will contribute especially much to e.g. disfavour the accelerator producing it. If so then the type of accelerator producing this type of particle – especially if in large numbers – should be prearranged not to come to work for long time in the mode producing the many such particles. In our model, we suggest that the type of particle causing the disfavour and giving thus especially bad luck for the running of the accelerator is the Higgs boson, because we think that the term $\dots + m_h^2 |I \cdot | \phi_H|^2 + \dots$ in the imaginary part of Lagrangian density

$$L_I(x) = \dots + m_h^2 |I \cdot | \phi_H|^2 + \dots, \quad (11)$$

is dominant from a dimensional argument. The imaginary part of the Lagrangian density $L_I(x)$ is of course the space time density for the imaginary part of the action

$$S_I[\text{path}] = \int_{\substack{\text{over all space time incl.} \\ \text{past and future}}} L_I(x, \text{path}(x)) \sqrt{g} d^4x. \quad (12)$$

Our “dimensional argument” is that if the natural units were the Planck units the natural value for quantity $m_h^2 |I$ having dimension of mass square would be the Planck mass $m_{\text{PL}} \sim 10^{19} \text{GeV}$ squared, i.e. $m_h^2 |I \sim (10^{19} \text{GeV})^2 \sim 10^{38} \text{GeV} = 10^{32} \text{TeV}^2$ which is tremendously large from the point of view of LHC-physics.

If an accelerator indeed has the potentiality of producing many of such “hated” or bad luck giving new particles we might observe it by investigating statistically if the

accelerators meet bad or good luck technically and politically. Here immediately the reader should think of the biggest potential (putative?) accelerator the SSC having been stopped in 1993 by the Congress.

As we have already suggested in earlier papers it might be difficult to get a clean statistical investigation of the potential bad luck unless one makes a very clean experiment by betting a card game preferably combined with quantum random numbers decide whether a certain accelerator – of course we propose it to be LHC – be brought to run and at what luminosity and energy.

6 Card game for LHC restrictions can only be a success!

There are two possibilities.

- 1) You draw a card combination of the most common type leading to no restrictions. Then LHC can run without any restriction and you can be totally happy because you found, with close to zero expense, an argument against our theory. You almost kill our theory, or at least drastically diminish the chance that it is right. This is a very good scenario!
- 2) You draw a restriction card combination. Now, it is a significant loss that LHC cannot run in full, but now you have proved our, or a similar, backward causation theory. This would be so interesting, if one really had backward causation, that it might be counted as a discovery greater than supersymmetric partners or the finding of the Higgs. It would be a fantastic discovery made with LHC! If the restriction drawn is not a total closing, you would likely soon also find the Higgs and perhaps the supersymmetric partners even if statistics might initially be a bit worse than hoped for.

It would be a wonderful victory for CERN and LHC to find backward causation together with having to obey the most likely very mild restrictions. We should remember that the rule of our card game should be to make the milder restriction have a much higher chance of being drawn than the very strong restriction of, for example, totally closing LHC.

Quite correctly, there is, though a little chance of, a true loss even though it will not be initially noticed. It is possible, although not likely, that a random number game leads to a restriction even if our model, and any model with backward causation, is wrong. In this case, we have a bad bargain: not only would we lose the full applicability of LHC, but we would also have gotten, by a statistical fluctuation, the wrong impression that a backward causation containing model were indeed true without this actually being the case.

We should certainly arrange the restriction probability p to be low enough to make this bad case have a very low probability.

One would, from this way of arguing, initially suspect that it would be most profitable not to perform our random number LHC restricting experiment because if our theory were right LHC would, in any case, be closed or restricted somehow by prearranged bad luck, as happened to SSC, for which Congress in the U.S.A. terminated economic support. Now, however, we want to argue that it would be more agreeable to have LHC be stopped or restricted by a random number game rather than by some bad luck such as political withdrawal of support. The main reason for the artificially caused random number withdrawal being preferred is that we would, in this case, get more solid support for our, or a similar, model being true than by the same restriction coming about through a bad luck accident.

To see that would be more convincingly shown the truth of our theory of imaginary action determined by history if we have a card or random number closure rather than a “normal” failure, we could contemplate how much more convincing our theory would have been today if the SSC-machine had been closed after a random number experiment rather than mainly for economical reasons or perhaps because of the collapse of the Soviet Union, which made the competition with 60 million dollar accelerators not worthwhile.

Now it is sometimes explained that SSC [15] had bad luck because of various stupidities or accidents, but had it been a card game such ideas would not matter. Everything is an accident, but we would know the probabilities very reliably. So if the card game were set up so that the closing probability were sufficiently small, we would have been sure that the closing of SSC were due to a (anti)miracle.

In the following, we shall present a little calculational example to illustrate formally that a more reliable knowledge of the truth of our theory is obtained with a

random number experiment. This comes under the discussion of point 2) among the reasons for conducting our proposed experiment later in the present article.

7 Reasons for conducting our proposed experiment

What could be a reason to conduct the card game experiment?

- 1) To obtain greater conviction about the truth of our theory
– if it is true of course. –
- 2) To perhaps avoid bad backward causation effects.

These are the two benefits you could have.

In formula it would mean that we should estimate averages for the two measures of these two benefits.

More conviction of truth of our model

For reason 1) – the conviction about our theory that it is indeed right – we need some measure. Both the result of the card game and the failure of the LHC for other reasons are statistical events, but, while we have very trustable ideas about what probability p to assign to a given class of card combinations, our assignment of a trustable value for the failure probability f for other reasons is very difficult and has a huge uncertainty. Therefore, if LHC fails for a reason other than a random number game, we would have not even truly learned that our theory was right even though we would say “it is remarkable that the present authors wrote about the failure while LHC still looked to be able to work.”

Miraculosity and estimating evidence for our model

In order to understand why the difference between getting our model supported by a “natural ” failure of LHC and a failure caused merely by having a card game drawing a “restrict LHC” card gives rise to an important difference in trustability in our model. We shall give a slight formal illustration using the statistical model which is not very exact but is appropriate for illustrating our point.

If, in our model, a seemingly other reason for failure of LHC occurs merely through the coincidence of a series of small bad luck events – that by themselves can easily happen – then the number and unlikeliness of elements in this series of bad luck events must be proportional to $-\ln f = |\ln f|$ where f is the probability of failure. We could call this quantity $-\ln f$ the “miraculosity” for failure in a seemingly natural way. This concept of “miraculosity” becomes a measure for how many “submiracles” must occur. As examples of submiracles, there are “the watch man having drunk a bit too much”, “the connection between super conducting cables having too high resistance”, “The accident being in the difficult part of the tunnel, just under Jura mountain” etc.

Now if we set up a card or quantum mechanically based random number generator leading to “restrict LHC” with probability p , it needs to generate – by the selection of the realized history in our model – a number of adjusted accidents (or submiracles) in a number proportional to $-\ln p = |\ln p|$. Essentially, in the case of the truth of our theory, whether the failure of the LHC will arise via the card or the quantum random number game or via a natural reason will depend on which of the two alternative miraculosities $-\ln p$ or $-\ln f$ is the smallest. There will, of course, be a preference with “miraculosity”: the least miraculous of the two alternative possibilities for failure will most likely be the one that occurs. This would require fewest submiracles.

We can define f so that indeed $-\ln f$ gives a measure of the “miraculosity”, but it is very difficult even for people building the LHC, to convincingly figure out what to accept or predict about this miraculosity $-\ln f = |\ln f|$. At best, one can predict it with an appreciable uncertainty. That is to say, we obtain, at least from some simulation – say by Monte Carlo methods or just theoretically – a probability distribution for “miraculosity” $|\ln f|$. To illustrate our point of estimating the degree of conviction, which we shall obtain in the case of a “natural” and/or “normal” failure, we can assume that the probability calculation – by (computer) simulation of the political and technical procedures around CERN and LHC – led to a Gaussian distribution for the miraculosity $-\ln f$. That is to say, we assume the probability

distribution

$$\begin{aligned}
P(|\ln f|) d|\ln f| &= \\
&\approx \frac{1}{\sigma\sqrt{2\pi}} \exp\left(\frac{1}{2\sigma^2} (|\ln f| - |\ln f_0|)^2\right) d|\ln f|.
\end{aligned} \tag{13}$$

Here, σ is the spread of the distribution for the logarithm of f , i.e., the “miraculosity.”

Now let us consider the degree of remarkableness for the failure depending on whether it is due to the card or the quantum random number game or a “normal” failure, i.e., other reasons such as meteors and bad electrical connection between the superconductors.

In the case of a card or quantum random number game, the number of sub-miracles in the card or quantum packing is proportional to $-\ln p$, where p is the arranged probability by the game rules.

However, if there is instead a “normal” failure due to the stupidity of some members of cabinet or the like, then we would tend, of course, to believe that the true miraculosity $-\ln f = |\ln f|$ for that failure is indeed in the low end of the estimated Gaussian distribution. In other words, we would expect that, after all, the “true” probability for failure f is rather high, i.e., $f > f_0$ or presumably even $f \gg f_0$.

Let us indeed evaluate the expected probability for a seemingly “normal” (i.e., not caused by card etc games) failure. This expected normal probability for failure is

$$\langle f \rangle = \int_{-\infty}^{\infty} \frac{1}{\sigma\sqrt{2\pi}} \cdot f \cdot \exp\left(-\frac{1}{2\sigma^2} (\ln f - \ln f_0)^2\right) d|\ln f| \tag{14}$$

(we imagine that the miscalculation by including the $f > 1$ region is negligible, but one could of course do better if needed).

We immediately write $f = e^{-|\ln f|}$. We had hoped to expect “normal” failure

with the probability given by

$$\begin{aligned}
\langle f \rangle &= \int_{-\infty}^{\infty} \frac{1}{\sigma\sqrt{2\pi}} \cdot \exp\left(-\frac{1}{2\sigma^2}(|\ln f| - |\ln f_o|)^2 - |\ln f|\right) d|\ln f| \\
&= \int_{-\infty}^{\infty} \frac{1}{\sigma\sqrt{2\pi}} \cdot \exp\left(-\frac{1}{2\sigma^2} \left[(|\ln f| - |\ln f_o| + \sigma^2)^2 \right. \right. \\
&\quad \left. \left. - \sigma^4 + 2\sigma^2|\ln f_o| \right] \right) d|\ln f| \\
&= \exp\left(\frac{\sigma^2}{2} - |\ln f_o|\right) = f_o e^{\sigma^2/2}.
\end{aligned} \tag{15}$$

Hence the remarkability or apparent miraculousness of the outcome that LHC should fail seemingly by a “normal” accident – such as political closure – is not the “miraculosity” corresponding to the most likely value for f , i.e., $-\ln f_o = |\ln f_o|$, but rather to “remarkableness” $= -\ln \langle f \rangle = |\ln \langle f \rangle| = |\ln f_o| - \frac{\sigma^2}{2}$.

It is this correction by the term $-\frac{\sigma^2}{2}$ that causes less conviction for our model being true if the failure of LHC shows up as a “normal” failure, than if we get a failure caused by a card or quantum random number game. One should keep in mind that whether in our model one or the other reasons for failure occurs depends largely on the relative sizes of $-\ln f$ and $-\ln p$.

In this way, it would be more convincing that our theory were true if the failure were found by a card game or the like than by a “normal” failure of LHC. It would thus be profitable scientifically if we could provoke a card game failure instead of a “normal” one; we would have the possibility of arranging that if our model were right. In the case of our model being wrong, of course, the card game project would only add to the totally failure probability of LHC, making a card game a risk and a bad thing.

Should our theory be right, the failure of LHC would be guaranteed with $\frac{2}{3}$ probability, and in that case, the chance of total failure probability would not change greatly whether we perform a card game project or not. In that case we would just move some failure probability from the “normal” failure due to the card game or the similar case.

If we place some economical value on the degree of confidence we would obtain if our model were indeed true depending on whether one failure or another really

occurred, we could put this benefit into the form

$$\begin{aligned}
b_{1)} &= c \cdot \text{“remarkableness”} \\
&= c \cdot \begin{cases} |\ln p| & \text{if game failure} \\ |\ln \langle f \rangle| = |\ln f_o| - \frac{\sigma^2}{2} & \text{if “normal” failure.} \end{cases}
\end{aligned} \tag{16}$$

In the case of our theory being right, which occurs with probability r , we estimated that LHC would be stopped with $\frac{2}{3}$ probability [1] so that this benefit will be calculated as an average,

$$\begin{aligned}
\langle b_{1)} \rangle &= c \cdot \text{“remarkableness”} \\
&= c \left\langle \left(\frac{p}{f+p} |\ln p| + \frac{f}{f+p} \left(|\ln f_o| - \frac{\sigma^2}{2} \right) \right) r \frac{2}{3} \right\rangle_{\text{Gauss}},
\end{aligned} \tag{17}$$

where the average $\langle \dots \rangle_{\text{Gauss}}$ is merely the average over distribution (13) .

For instance, in the limit of a very small probability p assigned to the random number restricting LHC, we would get

$$\langle b_{1)} \rangle \approx c \left(|\ln f_o| - \frac{\sigma^2}{2} \right) r \cdot \frac{2}{3} + cp \left\langle \frac{1}{f} \right\rangle \left(|\ln p| - |\ln f_o| + \frac{\sigma^2}{2} \right) r \frac{2}{3} + \dots \tag{18}$$

If, on the other hand, we set $p \gg \langle f \rangle$, we would get

$$\langle b_{1)} \rangle \approx \left(|\ln p| + \frac{\langle f \rangle}{p} \left(|\ln f_o| - \frac{\sigma^2}{2} - |\ln p| \right) \right) r \cdot \frac{2}{3}. \tag{19}$$

It is important to notice that, as the previous discussion suggested, the correction term in (18) will, for small enough p , give increasing benefit with increasing p so that it would be beneficial *w.r.t.* this benefit $b_{1)}$ of attaining an increase in the safety of our knowledge that p is not completely zero in our model.

8 Avoiding bad backwardly caused events

In our earlier paper, we included, in our estimates of whether it would pay to perform our card game or random number game experiment, the consideration that if we indeed have backward causation for LHC becoming inoperable, then these pre-arrangements could have side effects that might be bad and, a priori, perhaps also good. The backward causation effects might end up being huge in much the same way as the famous forward causation effect of the butterfly in the “butterfly effect”,

but in the same way as it is difficult to predict whether the effects are good or bad when the butterfly beats its wings in a particular way, it is hard to know if the pre-arrangements set up to prevent LHC from working are good or bad. If we think of such possibilities as the closure of CERN or an earthquake in Geneva, we may judge it to be bad, but if we think of even earlier or further distant pre-arrangements, it becomes increasingly difficult to estimate either good or bad. For instance, it is a possibility that a major factor behind the SSC being terminated by Congress was the collapse of the Soviet Union [16]. This were a huge backward causation effect but it is hard to evaluate the probability as to whether it is good or bad. Thus, it would have been hard to evaluate, in advance, whether our card game would have been profitable had our theory been known then.

In the previous articles [1], we called the price of the damage arising in excess when a “normal” failure of LHC is provoked, d .

We should imagine that the very huge backward causation effects occurring very remotely from the LHC are probably averaged out to zero, similar to the far future effects of the butterfly wing. Hence the important contributions to the damage cost d are rather close in time (and space) to the LHC itself. We very roughly estimated, in our previous study, $d \approx 10 \cdot \text{“cost of LHC”} \simeq 10 \cdot 3.3 \cdot 10^9 \text{ CHF} = 3.3 \cdot 10^{10} \text{ CHF}$.

In the case of the card game failure, there may also be huge effects, but now the evaluation of the damage being good or bad would be totally opaque. Only the effects of performing the actual experiment may have any predictable average effect. Therefore, in the case of such an artificial failure, the damage would be limited [to](#) statistically washing out damage (i.e., they are equally likely to be good or bad) and the obvious loss because of the restriction on the $d_{\text{rest.loss}}$ card drawn.

We should arrange the latter damage to almost certainly be the minimal one by assigning mild restrictions to be much more likely outcomes than heavy restrictions.

The damage done, or by switching the sign, the (negative) benefit, is

$$-b_2) = d \cdot \frac{2}{3}r \cdot \frac{f}{f+p} + d_{\text{rest.loss}} \cdot \left(p \left(1 - \frac{2}{3}r \right) + \frac{2}{3}r \cdot \frac{p}{f+p} \right), \quad (20)$$

where we used the notation $d_{\text{rest.loss}}$ for the cost of the restrictions.

9 Conclusion and outlook

We have discussed in this article two major topics in connection with our previously proposed model with the action assumed to be complex.

The first of these subjects could have been considered starting from the troubles of EPS problem the Bell's theorem which states that quantum mechanics makes predictions in the case of entangled particles being measured on that are in disagreement with seemingly very reasonable assumptions. There is however as noticed by Bell himself a way out for quantum mechanics if one makes use of that for given initial conditions the measurements which the experimentalists at the two discussed significantly separated positions A and B in the Bell or EPS experiment perform is already in principle determined by determinism of at least say classical approximation physics. This deterministically determined choice of experiment being performed namely makes the need for discussing simultaneously several possible choices (by "free will" so to speak) irrelevant. In our complex action model this point may be more stressed since the initial conditions are even in principle calculable.

However, we believe that it is NOT this true superdeterminism which makes our model with the complex action more able to cope with the Bell's theorem problem, but rather the fact that our model predicts that *the measurement results depend on the happening in the future!* It is this backward causation property of our model which makes the assumption of no signal going faster than the speed of light being a prerequisite for Bell's theorem not trustable in our model. The point is that if the future can influence the past by making an adjustment of the initial conditions or by as is here relevant influence the outcome of a measurement, then a genuine signal coming along with less than speed of light from A to B is not needed. Instead we can have an effect from the future which is influenced by a signal from A. But if one can wait to get the signal to somewhere in the future of course there is no need for the signal reaching along faster than light. It has time enough to reach the future, just influence can go backward in time there is no hurry to get the signal along. Actually we found that our model essentially reproduces in a second quantized version in principle calculable classical fields which can be identified with the wavefunctions including echoes from future in the transactional interpretation. To our model is with respect to the essential picture identical to the transactional interpretation model, although we do not have exactly the Feynman-Wheeler time

reflection invariant emission exactly. Rather our influence from future is determined by parameters in the imaginary part of the action.

Thus we claimed that actually the Bell's trouble calls for the influence from future effect, and thus one should really attempt to look for such backward in time influences whenever some new region of physics is being explored. Using our special model of complex action the obvious place to look for such effects namely the at a given time highest energy accelerator gets especially suggested. So we should look for such effects by means of LHC.

We have argued that it would be a good idea to perform our earlier proposed experiment of generating some random numbers – by card drawing or by a quantum random number generator, or even both ways – and letting them then be decisive in applying restrictions on the beam energy and/or the luminosity and/or the like.

The main point was that our theory, referred to as “model with an imaginary part of the action”, is indeed seen to be right if LHC is stopped by our proposed game rather than if it just failed for some technical or political reason. The reason for the suggestion of our model being right if the LHC were stopped by a random number (card) game decision than by just a “normal” technical or political failure is that it is very hard to estimate in advance how likely it is for a “normal” failure of LHC to occur.

The greatest encouragement for performing the experiment without much hesitation is the remark that whatever happens with our proposed experiment, it will, in practice, seem to be a success or at least to be of no harm. The point is that in the case of any restriction being imposed by the random numbers, we have, because of the very fact of these random numbers being generated at all, obtained the shocking great discovery that there is “backward causation.” Such a discovery of the future influencing the present and past would be monumental. Consequently, we would be very happy and it would be a fantastic success for the LHC to have caused such a discovery!

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